

## NUMERICAL SIMULATIONS OF COLLISION BEHAVIORS OF OPTICAL SOLITONS IN A KERR LAW MEDIA

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### ABSTRACT

Optical solitons are well thought-out as natural bits for telecommunications as they have the inclination to preserve their shape over transoceanic distances. In order to achieve stability, there should be a balance between the group velocity dispersion (GVD) which causes pulse broadening and the self phase modulation (SPM) which causes spectrum broadening. The time interval  $T_B$  between two adjacent bits or pulses determines the bit rate of a communication system as  $B = 1/T_B$ . It is thus imperative to study how close two solitons can come without affecting each other. In this paper soliton collision in nonlinear optical fibers are investigated.

**KEYWORDS:** SPM, GVD, SOLITON

### INTRODUCTION

The increased bandwidth demand has fascinated attention of the researchers to discover new avenues to streamline the suffocated bits in the bandwidth pipeline. The fiber losses, dispersion and fiber nonlinearities are the limiting factors of optical communication system design. The higher bit rate requires the use of short pulses, which have inherited nonlinearities. Ultimately, optical solitons [1-2] will be the eventual candidate, which use the nonlinear self phase modulation to counteract the group velocity dispersion (GVD). For an precise system the fiber nonlinearities can be balanced by GVD whereas fiber losses can be compensated by periodic or distributed amplification. However, increased channel capacity requires the pulses to be closely spaced. It is therefore necessary to investigate interaction [3-7] between co-propagating soliton pulses. In this work, various simulation experiments have been performed using Matlab to examine the interaction involving two neighboring solitons of equal amplitude, unequal amplitude by varying the phase [8-9] between them. Also the interactions between neighboring solitons by varying the spacing and amplitude has been investigated.

### MATHEMATICAL MODELING FOR SOLITON INTERACTION

The equation which govern soliton is the Non-linear Schrodinger equation (NLSE) for an optical pulse with the field envelope  $u(z,t)$  propagating in the optical fiber with the no loss and higher order dispersion is given in [3,4,5] as

$$\frac{du}{dz} = -\frac{i}{2}\beta_2 \frac{d^2u}{dt^2} + |u|^2u \quad (1)$$

Where  $\beta_2$  is the second order dispersion parameter. By solving the equation numerically with the input amplitude consisting of a soliton pair [1] we can find the outcome of interaction on solitons. The solutions of the NLS [12-15] allow investigation of different amplitude and phases associated with a soliton pair by using the following form at the input end

of fiber

$$u(0, \tau) = \text{sech}(\tau - q_0) + r \text{sech}(\tau + q_0) e^{i\theta} \quad (2)$$

And when we examine interaction between three solitons the solutions of the NLS allow by using the following form at the input end of fiber

$$u(0, \tau) = \text{sech}(\tau) + \text{sech}(\tau - q_0) + r \text{sech}(\tau + q_0) e^{i\theta} \quad (3)$$

Where  $q_0$  is the center of pulse,  $r$  is the relative amplitude,  $\theta$  is the relative phase between neighboring solitons.

## SIMULATION RESULTS

The effect of varying the phase, amplitude and spacing between neighboring solitons has been studied with Matlab using equation (2) results are:

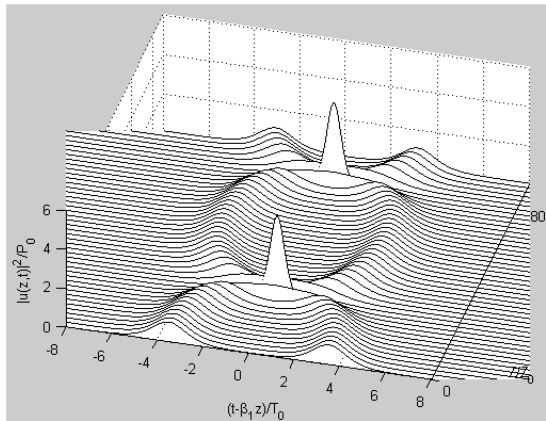


Figure 1:  $r=1, \theta=0$

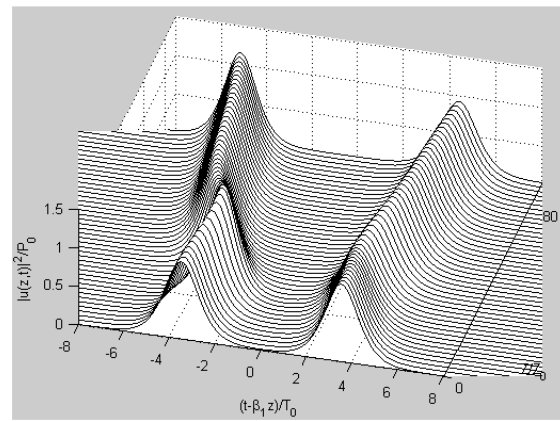


Figure 2:  $r=1, \theta=\pi/4$

In the case of the same amplitude solitons the solitons attract each other in the in phase case and collide periodically along the fiber length. For  $\theta = \pi/4$ , the soliton separate from each other after early attraction

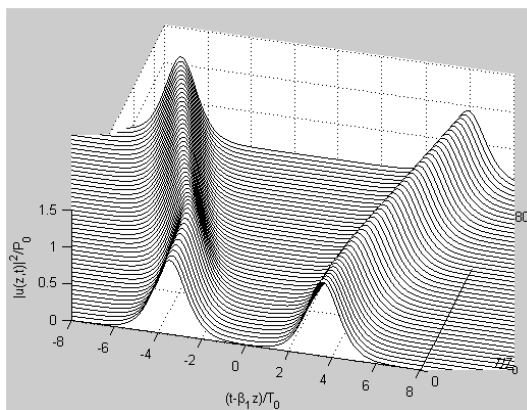


Figure 3:  $r=1, \theta=\pi/2$

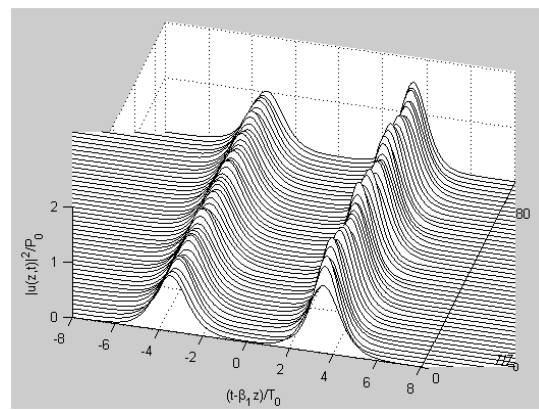
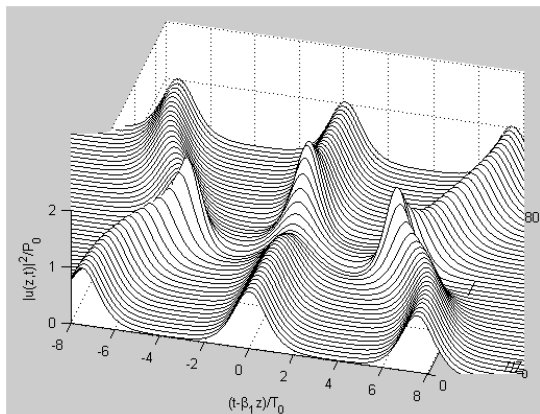
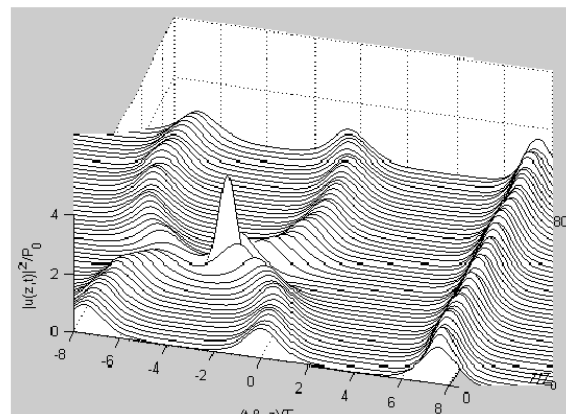


Figure 4:  $r=1.11, \theta=0$

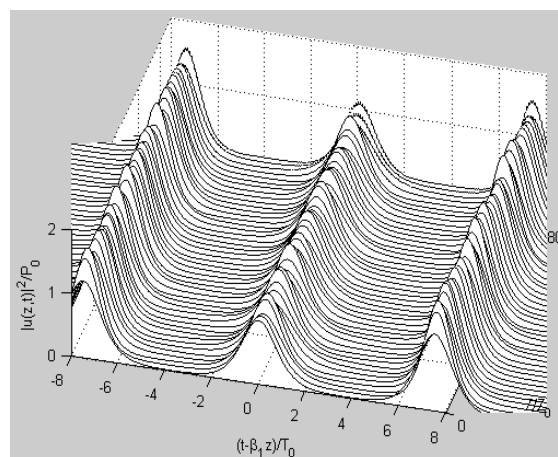
For  $\theta = \pi/2$ , the solitons repel more strongly. When solitons have different amplitude, in phase solitons oscillate periodically but never collide and move far away from each other.

And when using equation (3) simulation results are:


 Figure 5:  $r = 1, \theta = 0$ 

 Figure 6:  $r = 1.1, \theta = 0$ 

And when the input pulse is of the form

$u(0, \tau) = \text{sech}(\tau) + r \text{sech}(\tau - q_0) + r \text{sech}(\tau + q_0)$  the simulation result shows:


 Figure 7:  $r = 1.1, \theta = 0$ 

The periodic collision of neighboring solitons is unwanted from practical point of view. One way to avoid collision is to increase the soliton separation but this will have great impact on bandwidth another way is to change the phase and amplitude of the neighbouring solitons.

## CONCLUSIONS

In this paper, we have revealed through simulation two important phenomena's one that solitons are stable pulses and maintain their shapes even after interaction with each other. Due to these stable phenomena, they are resistant to fiber losses and are becoming base for very high speed optical networks. In order to avoid interaction, the phase, the choice of amplitude and spacing should be taken into concern since interaction decrease the efficiency of soliton transmission.

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